APPENDIX B

SUPER MODEL OUTPUTS

Updating Red River SUPER Model: Lake Texoma Yield Analysis and Water Supply Reallocation

Overview of SUPER Model

The SUPER Model is a suite of computer programs written for use in the Southwestern Division of the U.S. Army Corps of Engineers to model multi-purpose reservoir system regulation. The programs were developed over a thirty-year period by Ronald L. Hula, primarily as a planning tool to perform period-of-record analysis to evaluate changes in operational scenarios. The model has the ability to simulate flood control operations, and conservation pool operations including hydropower, water supply, water quality, diversions, and returns. In addition to period-of-record analysis, it has the capability to perform conservation pool yield analysis, and firm energy analysis. It also has the capability to develop unregulated conditions models, simulating systems with some or all reservoirs "dummied" out or non-existent. Besides system modeling, SUPER can perform economic analyses of impacts between plans. It can also provide a wide variety of output from which to evaluate scenarios including tabular or graphical formats of hydrographs, duration plots, and frequency curves at all reservoirs and control points within the system model.

SUPER is a daily simulation model that assumes all reservoirs are in place for the entire period of record specified for each model, based on data availability. For each SUPER model, a complex set of intervening area flows is developed for the entire period of record. This is the culmination of the pre-processing of data, before any simulation is done. When simulation is begun, headwater reservoir inflows and subsequent derived releases based on current and future forecast conditions, are then routed through the system on a daily basis. These routed flows are combined with intervening area flows at all control point locations. Reservoir releases are made for flood control, hydroelectric power generation, water supply requirements, and stream flow requirements such as water quality and irrigation. Other regulating considerations include channel capacities and bank stability. All releases are analyzed to determine their impact on current and future forecasted conditions, and are adjusted as needed to meet predefined system constraints. In addition to the above requirements, SUPER works to achieve a target uniform balance between all competing reservoirs during the draw down of system flood storage, and a target uniform balance in system conservation storage remaining during a conservation pool draw down. SUPER has evolved to meet the complex challenge of modeling system operations while meeting system and local constraints, and balancing requirements.

SUPER Hydrologic Development

Prior to this study, the Red River SUPER model had a hydrologic period-of-record from January 1938 to December 1990. Although there had not been any significant floods along the Red River through most of the 1990's, there had been some drier years, and enough additional years of record, that the model needed to be updated. The goal of this update was to extend the period of record to 2000.

This required collecting and formatting an additional ten years of daily inflows for the 20 reservoirs within the model, and daily flows for numerous flow gages used to develop the period-of-record hydrology. Monthly evaporation and precipitation at numerous locations was also collected and formatted. The data was extracted as much as possible from the USGS published data. Reservoir inflows, data for unpublished gages, and some evaporation data was taken from the internal Corps of Engineers databases. All required data was input into the Red River SUPER database.

After the Red River SUPER database was updated and complete, extensive editing of the hydrologic files was done to incorporate and utilize the additional ten years of daily data that was available. Hydrologic building files were then run through a series of programs to develop the updated period-of-record hydrology or local flows.

With the updated hydrology files, a natural conditions run, simulating no reservoirs in place, was made. As a final check to spot errors in building the hydrology file, a volume checking program was run, which performs a volume comparison between the natural condition flows developed from SUPER and observed gaged flow data. This required building an extensive input file to perform the volume checking analysis. Problems were corrected as required.

Texoma Yield Analysis Using SUPER

With the updated SUPER model, it was desired to determine the true yield of the conservation storage available at the end of the project life. The yield of the conservation storage is required to determine the critical dependable water supply demand that will occur if the entire reallocated storage is used for water supply. This will provide a worse case demand for water supply during the critical drought. At Lake Texoma the conservation storage lies between El. 590 and 617. The end of the project life at Texoma is the year 2044. The water supply yield run was made using an updated elevation-area-capacity table based on the 2002 sediment resurvey of Lake Texoma, with projected future sedimentation to the year 2044. This projected future storage is considered “usable storage”. The true yield of the conservation storage at Lake Texoma for the projected 2044 conditions was determined to be 1502.5 cfs. The critical dependable yield for the conservation storage allocated to water supply is determined based on the following equation:

$$\text{Critical Dependable Yield for Allocated Water Supply Storage} = \frac{\text{Total Allocated Water Supply Storage}}{\text{Total “Usable” Conservation Storage(in 2044)}} * \text{True Yield}$$

$$\text{For the full 300,000 ac-ft reallocation, the Critical Dependable Water Supply Yield} = \frac{\text{150,000 ac-ft (past) + 300,000 ac-ft (present)}}{\text{986,730 ac-ft}} * \text{1502.5 cfs}$$

$$= \text{685.2 cfs or 442.1 mgd}$$

Current water supply contracts based on the 1985 sediment survey with sediment projections to the year 2044 will need to be updated to the current “usable storage” based on the 2002 sediment survey at Texoma.

Texoma Water Supply Reallocation Runs Using SUPER

Three SUPER runs were made to model impacts at Texoma due to the current reallocation of hydropower to water supply. The critical dependable water supply demand is the only input parameter that varies between the runs. The runs made are as follows:

(1) Existing conditions in which the full 150,000 ac-ft previously reallocated from hydropower to water supply at Texoma is utilized. The water supply demand modeled = 228.4 cfs

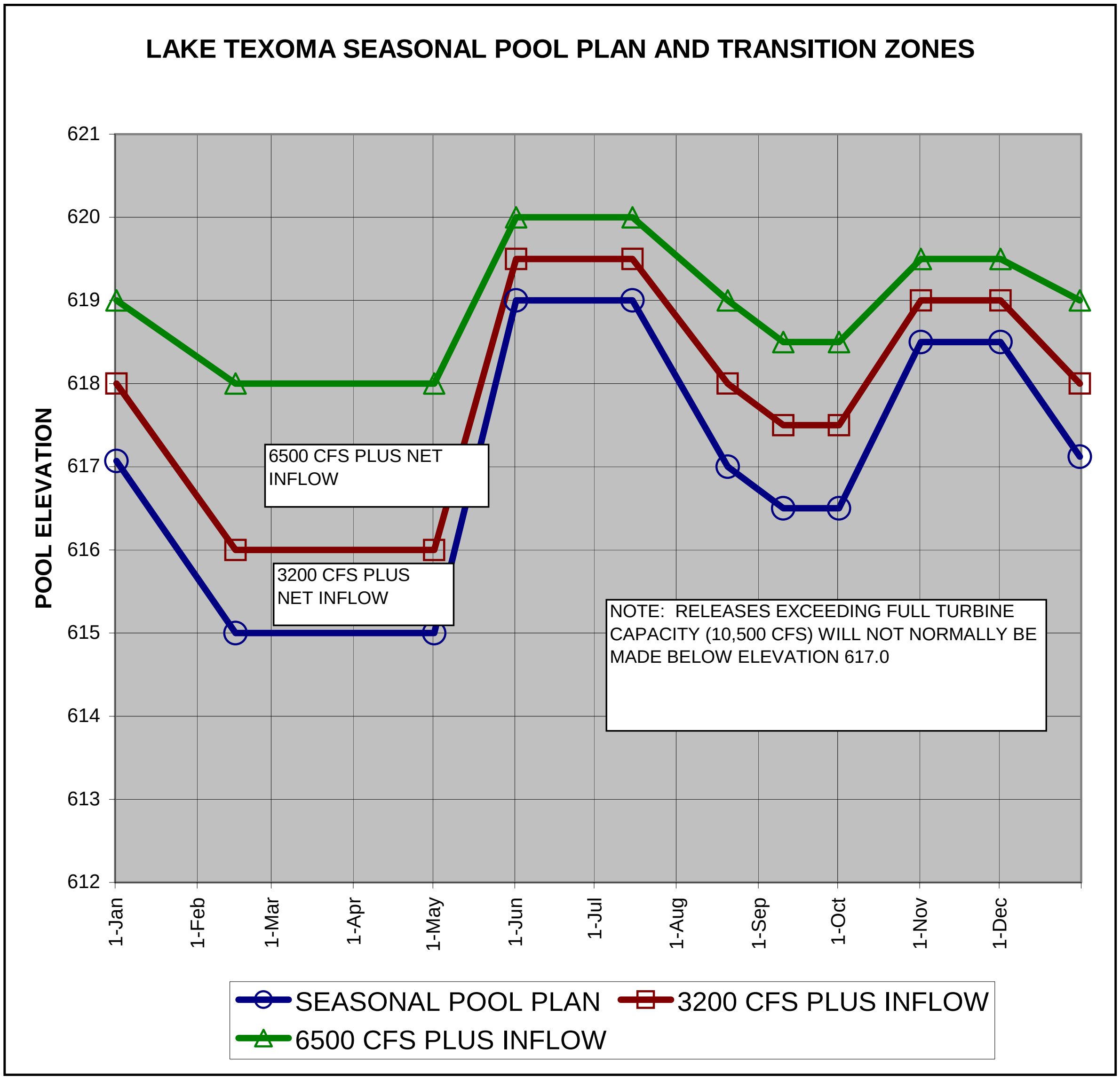
(2) Modified conditions in which the previous 150,000 ac-ft of reallocated water supply storage is utilized at Texoma plus half of the current Texoma water supply reallocation of 300,000 ac-ft (150,000 ac-ft for Texas and 150,000 ac-ft for Oklahoma). Therefore the total water supply demand for Texoma modeled in this run is 300,000 ac-ft. This

modified conditions run basically models Texas fully utilizing their water supply demand. The water supply demand modeled = 456.8 cfs

(3) Modified conditions in which the previous 150,000 ac-ft of reallocated water supply storage is utilized at Texoma plus all of the current Texoma water supply reallocation of 300,000 ac-ft. The total water supply demand for Texoma modeled in this run is 450,000 ac-ft. This run models fully utilized water supply conditions at Texoma or the worst case scenario, for demands on Texoma. The water supply demand modeled = 685.2 cfs.

These runs were all done with the updated 2002 Lake Texoma Elevation-Area-Capacity table, with the updated Texoma seasonal pool guide curve (see Figure 1), and the extended period of record hydrology through 2000. To avoid too large a drawdown at Texoma with the larger water supply demands, Southwest Power Administration modified their hydropower loads input into SUPER, to reflect more realistically how they would operate, given the greater water supply demands. Therefore, these runs reflect modified hydropower loads for each scenario. The water supply demand at Texoma is modeled as a constant year-round demand. Results of the runs are provided in graphical form as attachments.

FIGURE 1. Texoma Seasonal Pool



Attachments

Figure 2 **Texoma Comparative Elevation-Frequency Curve between Super Runs A03X07A, A03X08A, and A03X09A**

Figure 3 **Texoma Comparative Elevation-Duration Curve between Super Runs A03X07A, A03X08A, and A03X09A**

Figure 4 **Texoma Outflow Comparative Flow-Frequency Curve between Super Runs A03X07A, A03X08A, and A03X09A**

Figure 5 **Texoma Outflow Comparative Flow-Duration Curve between Super Runs A03X07A, A03X08A, and A03X09A**

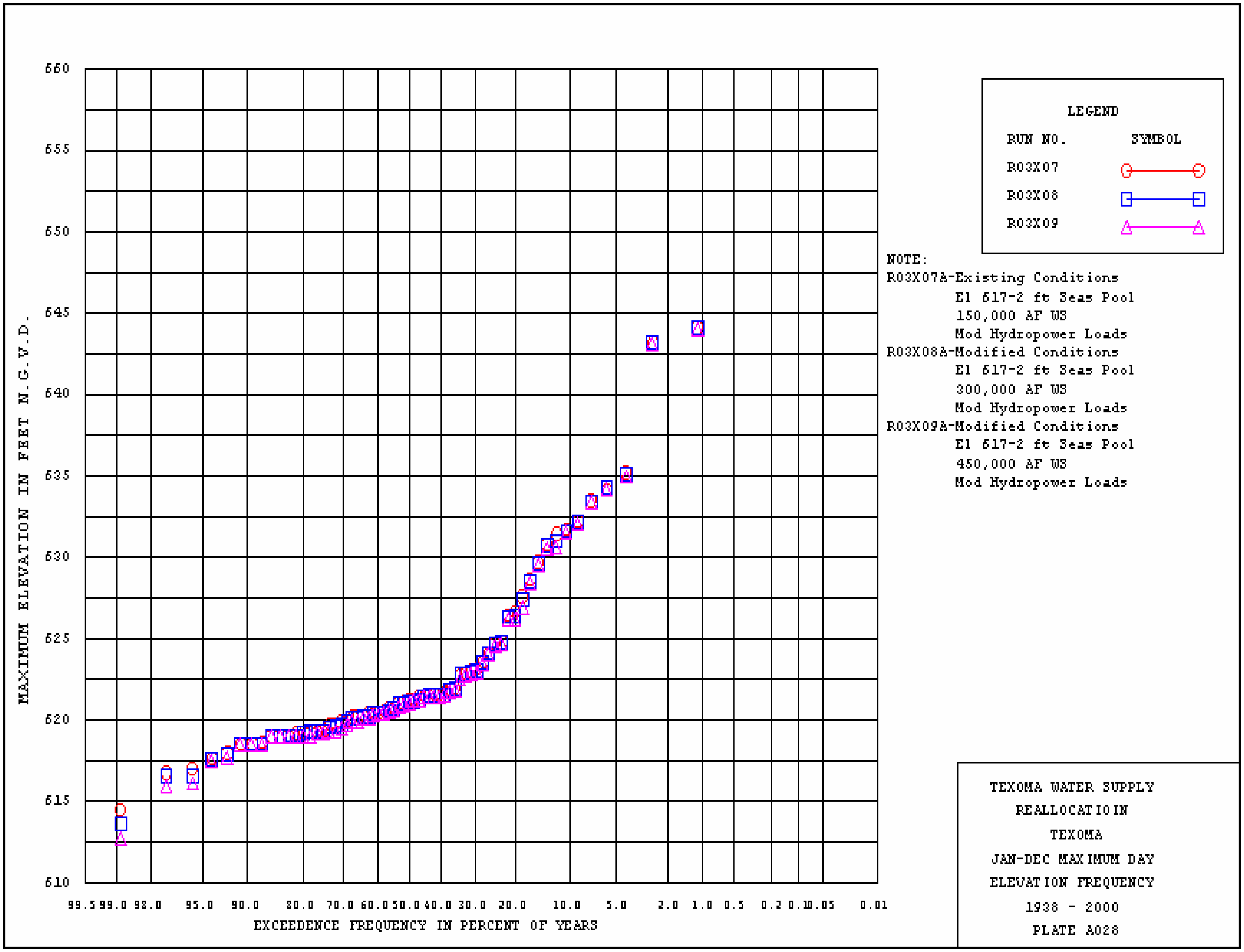
Figure 6 **Arthur City Comparative Flow-Frequency Curve between Super Runs A03X07A, A03X08A, and A03X09A**

Figure 7 **Arthur City Comparative Flow-Duration Curve between Super Runs A03X07A, A03X08A, and A03X09A**

Figure 8 **Texoma Comparative Minimum Elevation-Frequency Curve between Super Runs A03X07A, A03X08A, and A03X09A**

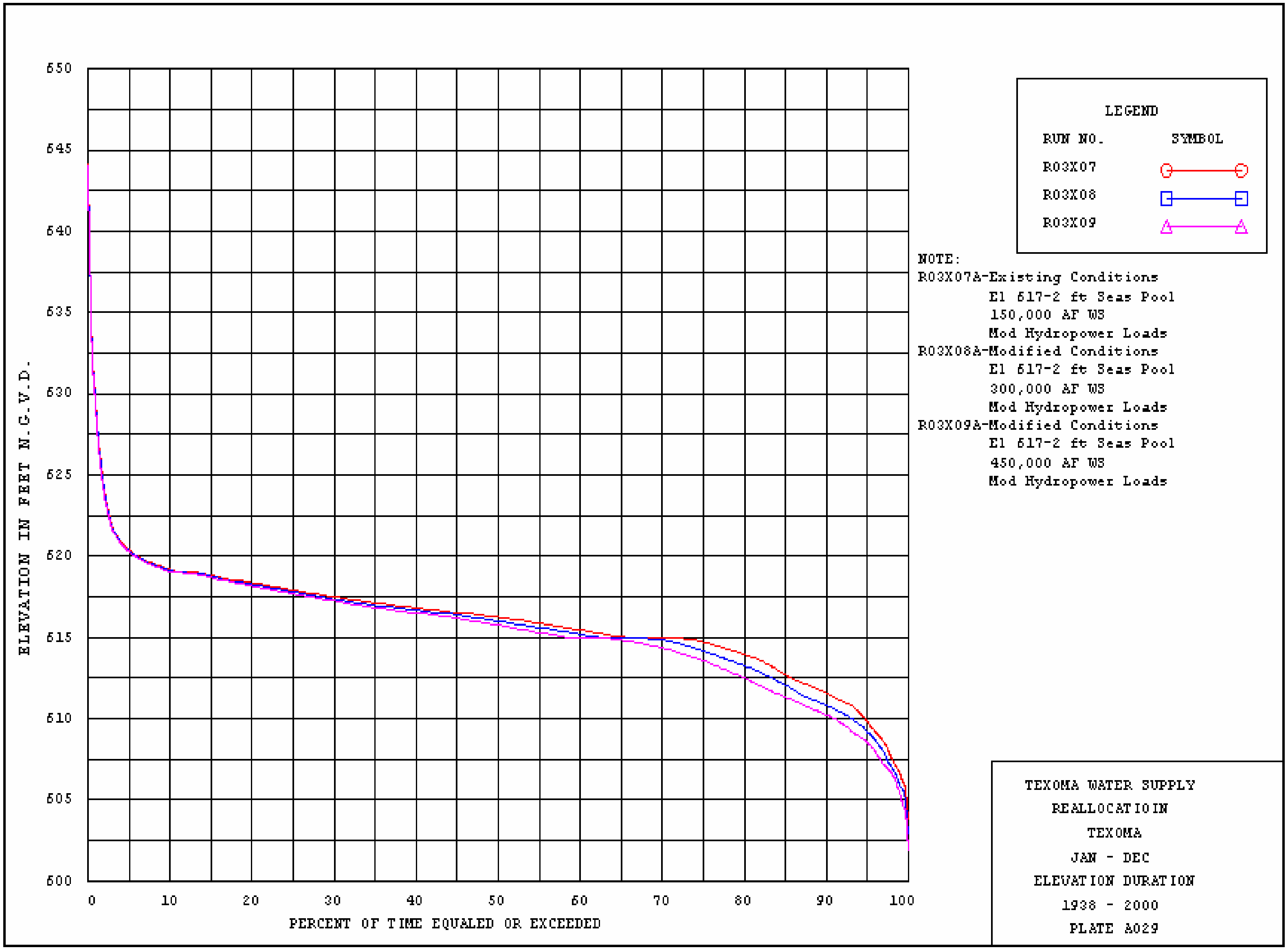
Figure 9 **Arthur City Comparative Minimum Flow-Frequency Curve between Super Runs A03X07A, A03X08A, and A03X09A**

FIGURE 2



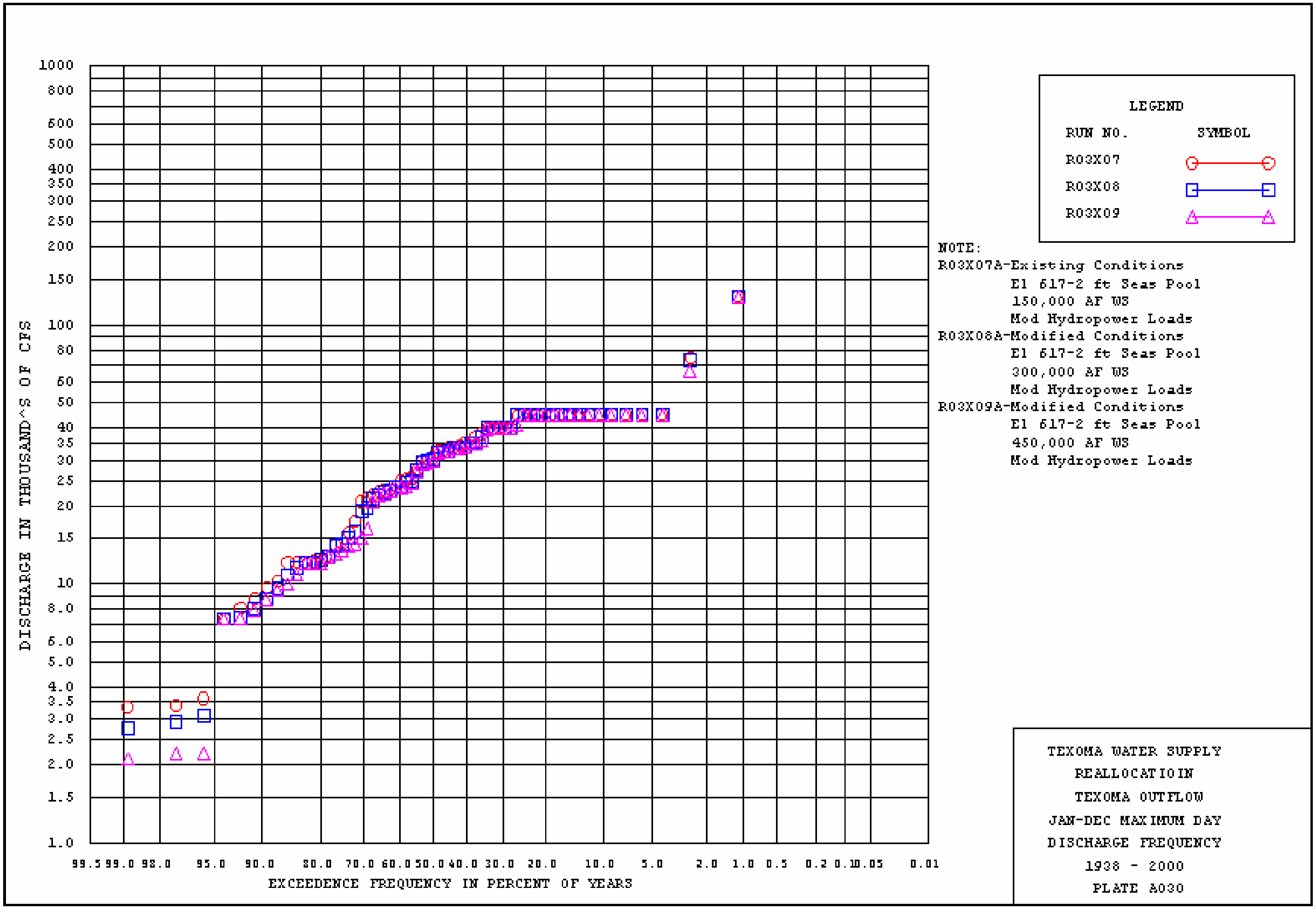
MAXIMUM ELEVATION IN FEET N.G.V.D.
660
655
650
645
640
635
630
625
620
615
610
99.5 99.0 98.0 95.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 5.0 2.0 1.0 0.5 0.2 0.1 0.05 0.01
EXCEEDENCE FREQUENCY IN PERCENT OF YEARS
LEGEND
RUN NO. SYMBOL
R03X07
R03X08
R03X09
NOTE:
R03X07A-Existing Conditions
El 617-2 ft Seas Pool
150,000 AF WS
Mod Hydropower Loads
R03X08A-Modified Conditions
El 617-2 ft Seas Pool
300,000 AF WS
Mod Hydropower Loads
R03X09A-Modified Conditions
El 617-2 ft Seas Pool
450,000 AF WS
Mod Hydropower Loads
TEXOMA WATER SUPPLY
REALLOCATIOIN
TEXOMA
JAN-DEC MAXIMUM DAY
ELEVATION FREQUENCY
1938 - 2000
PLATE A028

FIGURE 3



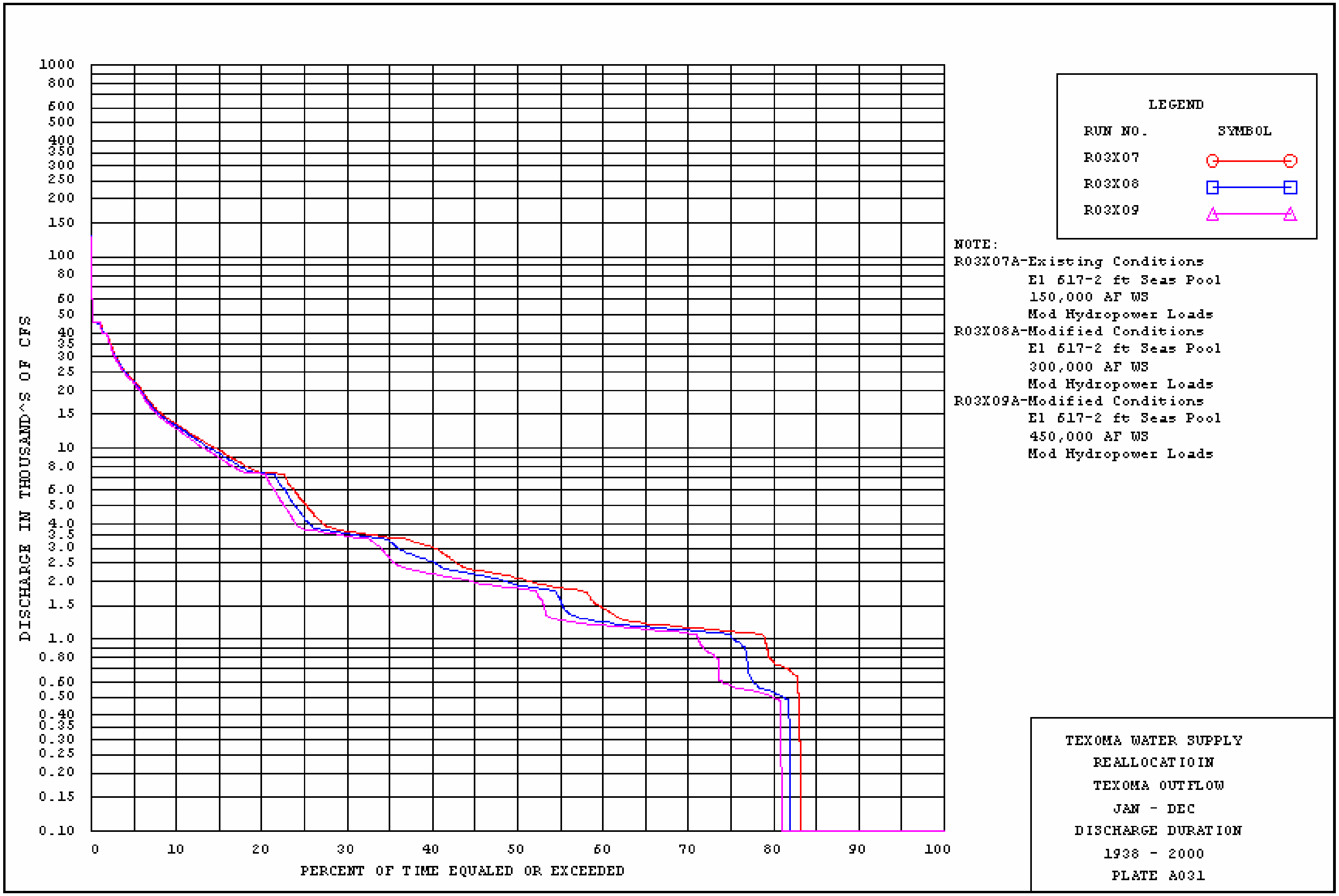
650
645
640
635
630
625
620
615
610
605
600
ELEVATION IN FEET N.G.V.D.
0
10
20
30
40
50
60
70
80
90
100
PERCENT OF TIME EQUALED OR EXCEEDED
LEGEND
RUN NO.
SYMBOL
R03X07
R03X08
R03X09
NOTE:
R03X07A-Existing Conditions
El 617-2 ft Seas Pool
150,000 AF WS
Mod Hydropower Loads
R03X08A-Modified Conditions
El 617-2 ft Seas Pool
300,000 AF WS
Mod Hydropower Loads
R03X09A-Modified Conditions
El 617-2 ft Seas Pool
450,000 AF WS
Mod Hydropower Loads
TEXOMA WATER SUPPLY
REALLOCATIOIN
TEXOMA
JAN - DEC
ELEVATION DURATION
1938 - 2000
PLATE A029

FIGURE 4



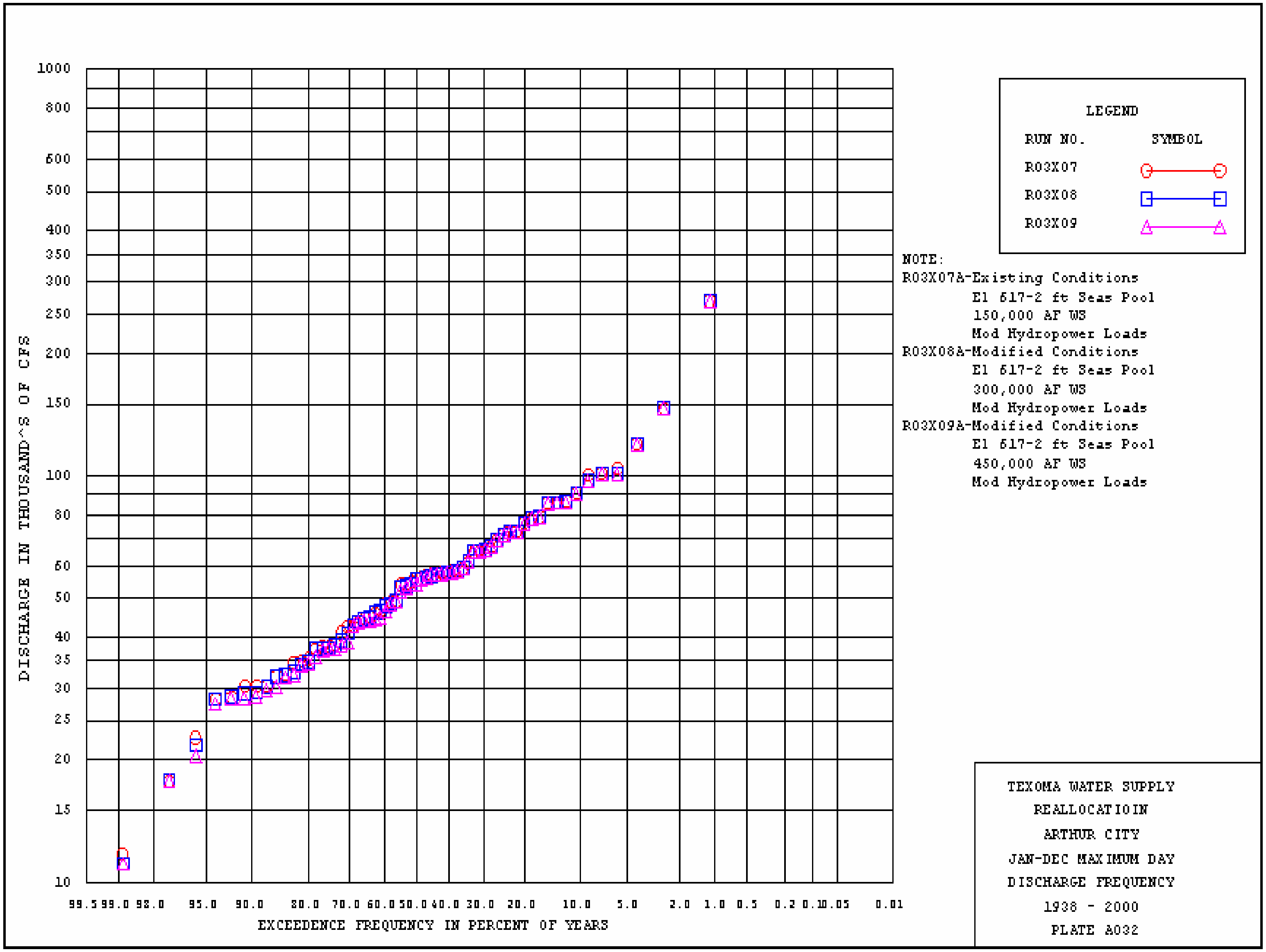
1000
800
600
500
400
350
300
250
200
150
100
80
60
50
40
35
30
25
20
15
10
8.0
6.0
5.0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
DISCHARGE IN THOUSAND^S OF CFS
99.5 99.0 98.0 95.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 5.0 2.0 1.0 0.5 0.2 0.1 0.05 0.01
EXCEEDENCE FREQUENCY IN PERCENT OF YEARS
LEGEND
RUN NO.
SYMBOL
R03X07
R03X08
R03X09
NOTE:
R03X07A-Existing Conditions
El 617-2 ft Seas Pool
150,000 AF WS
Mod Hydropower Loads
R03X08A-Modified Conditions
El 617-2 ft Seas Pool
300,000 AF WS
Mod Hydropower Loads
R03X09A-Modified Conditions
El 617-2 ft Seas Pool
450,000 AF WS
Mod Hydropower Loads
TEXOMA WATER SUPPLY
REALLOCATIOIN
TEXOMA OUTFLOW
JAN-DEC MAXIMUM DAY
DISCHARGE FREQUENCY
1938 - 2000
PLATE A030

FIGURE 5



DISCHARGE IN THOUSAND^S OF CFS
1000
800
600
500
400
350
300
250
200
150
100
80
60
50
40
35
30
25
20
15
10
8.0
6.0
5.0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.80
0.60
0.50
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0
10
20
30
40
50
60
70
80
90
100
PERCENT OF TIME EQUALED OR EXCEEDED
LEGEND
RUN NO.
SYMBOL
R03X07
R03X08
R03X09
NOTE:
R03X07A-Existing Conditions
El 617-2 ft Seas Pool
150,000 AF WS
Mod Hydropower Loads
R03X08A-Modified Conditions
El 617-2 ft Seas Pool
300,000 AF WS
Mod Hydropower Loads
R03X09A-Modified Conditions
El 617-2 ft Seas Pool
450,000 AF WS
Mod Hydropower Loads
TEXOMA WATER SUPPLY
REALLOCATIOIN
TEXOMA OUTFLOW
JAN - DEC
DISCHARGE DURATION
1938 - 2000
PLATE A031

Figure 6



DISCHARGE IN THOUSAND^S OF CFS
1000
800
600
500
400
350
300
250
200
150
100
80
60
50
40
35
30
25
20
15
10
99.5 99.0 98.0 95.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 5.0 2.0 1.0 0.5 0.2 0.1 0.05 0.01
EXCEEDENCE FREQUENCY IN PERCENT OF YEARS
LEGEND
RUN NO. SYMBOL
R03X07
R03X08
R03X09
NOTE:
R03X07A-Existing Conditions
El 617-2 ft Seas Pool
150,000 AF WS
Mod Hydropower Loads
R03X08A-Modified Conditions
El 617-2 ft Seas Pool
300,000 AF WS
Mod Hydropower Loads
R03X09A-Modified Conditions
El 617-2 ft Seas Pool
450,000 AF WS
Mod Hydropower Loads
TEXOMA WATER SUPPLY
REALLOCATIOIN
ARTHUR CITY
JAN-DEC MAXIMUM DAY
DISCHARGE FREQUENCY
1938 - 2000
PLATE A032

FIGURE 7

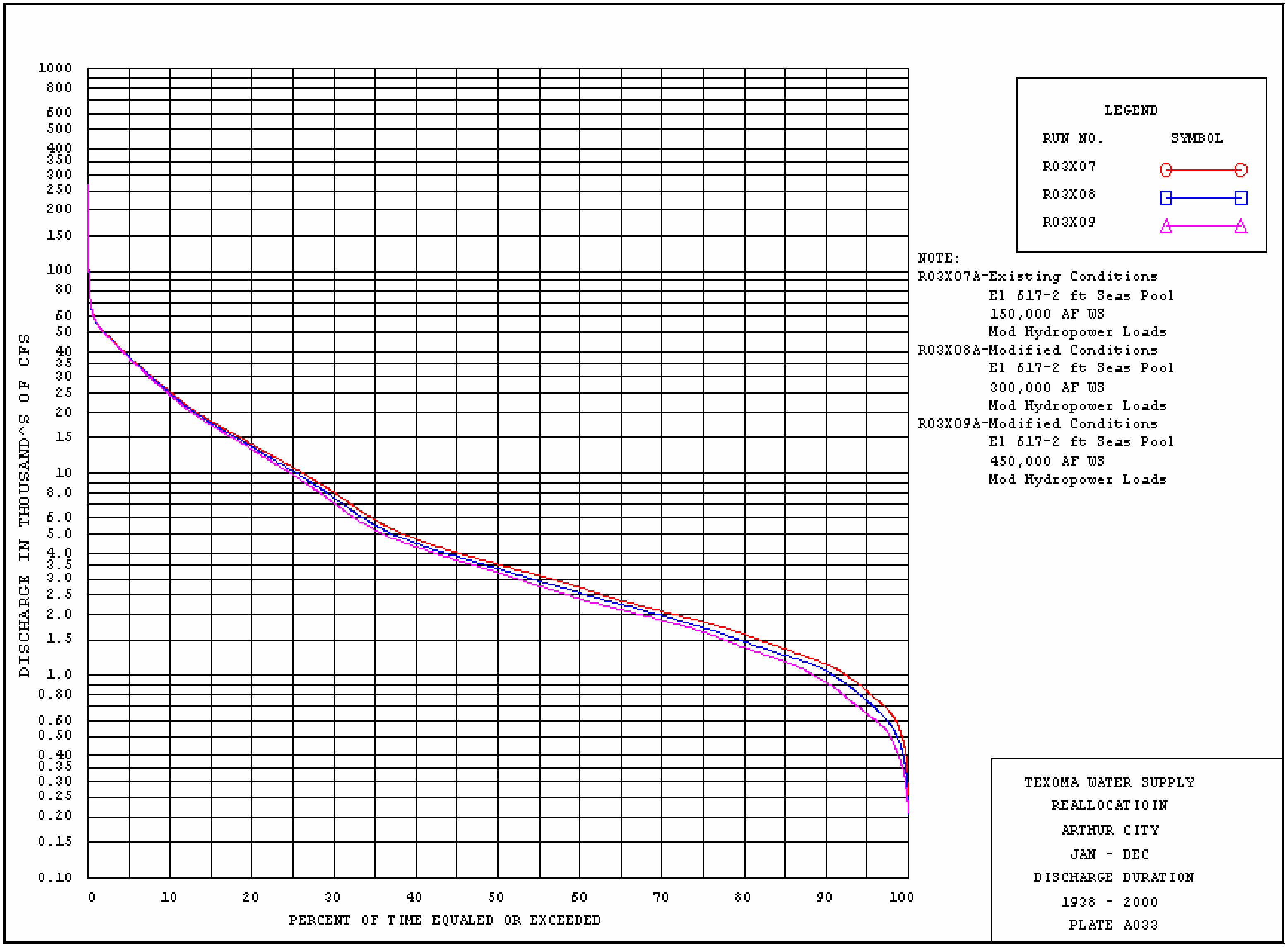
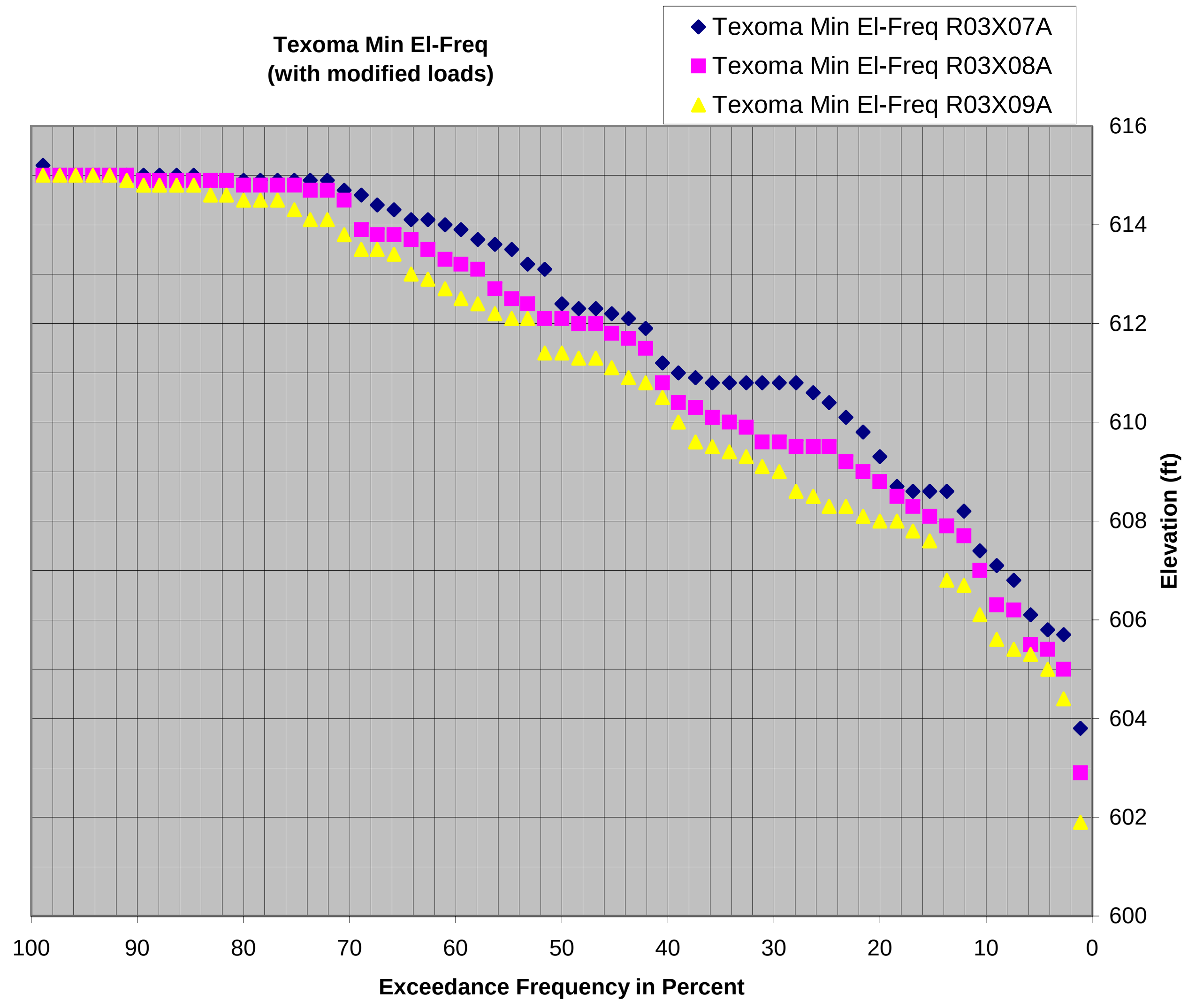
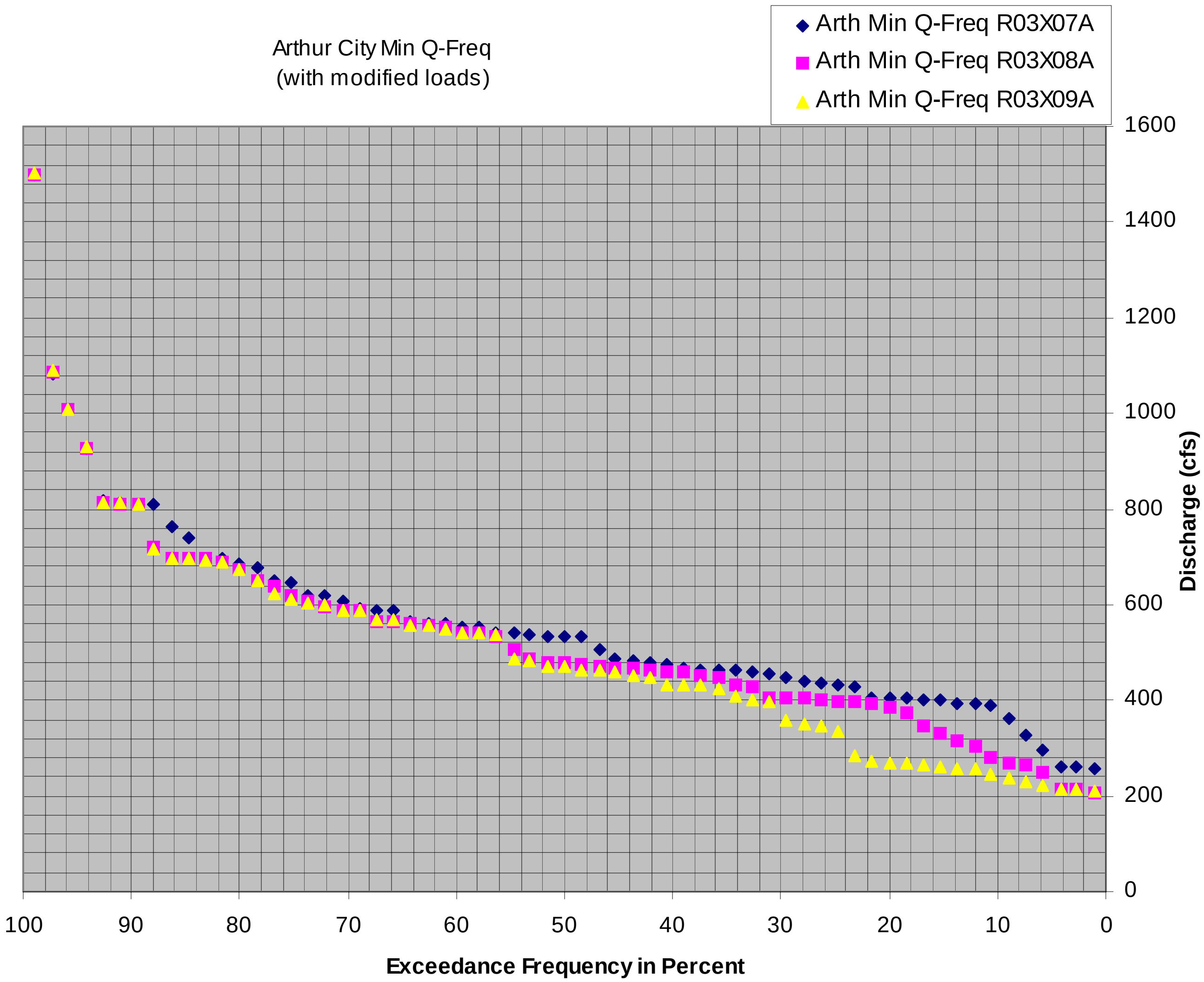

LEGEND
RUN NO.
SYMBOL
R03X07
R03X08
R03X09
NOTE:
R03X07A-Existing Conditions
El 617-2 ft Seas Pool
150,000 AF WS
Mod Hydropower Loads
R03X08A-Modified Conditions
El 617-2 ft Seas Pool
300,000 AF WS
Mod Hydropower Loads
R03X09A-Modified Conditions
El 617-2 ft Seas Pool
450,000 AF WS
Mod Hydropower Loads
DISCHARGE IN THOUSAND^S OF CFS
PERCENT OF TIME EQUALED OR EXCEEDED
0
10
20
30
40
50
60
70
80
90
100
1000
800
600
500
400
350
300
250
200
150
100
80
60
50
40
35
30
25
20
15
10
8.0
6.0
5.0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.80
0.60
0.50
0.40
0.35
0.30
0.25
0.20
0.15
0.10
TEXOMA WATER SUPPLY
REALLOCATIOIN
ARTHUR CITY
JAN - DEC
DISCHARGE DURATION
1938 - 2000
PLATE A033

FIGURE 8



Texoma Min El-Freq
(with modified loads)
Texoma Min El-Freq R03X07A
Texoma Min El-Freq R03X08A
Texoma Min El-Freq R03X09A
616
614
612
610
608
606
604
602
600
Elevation (ft)
100
90
80
70
60
50
40
30
20
10
0
Exceedance Frequency in Percent

FIGURE 9



Arthur City Min Q-Freq
(with modified loads)
Arth Min Q-Freq R03X07A
Arth Min Q-Freq R03X08A
Arth Min Q-Freq R03X09A
1600
1400
1200
1000
800
600
400
200
0
Discharge (cfs)
100
90
80
70
60
50
40
30
20
10
0
Exceedance Frequency in Percent

THIS PAGE INTENTIONALLY LEFT BLANK.